Update of an Occupational Asthma-specific Job-Exposure Matrix to assess exposure to 30 specific agents

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Figure E1 – Summary of the principles of exposure evaluation by the Asthma-specific JEM

Exposure estimate in yes (1) or no (0) for each ISCO-88 code					
ISCO88 job codes	18 asthmagenic products (high probability)			4 other exposures (Low asthma risk)		**Expert re-evaluation**
	(1)*	(2) ° …	(18)	(1) …	(4)	
5132, personal care workers	1	1 …	0	0 …	0	**0**
2221, doctors	0	0 …	0	0 …	0	**1**

* Reactive cleaning /disinfecting products, ° latex

YES

Job poorly defined or with heterogeneous exposure

NO

Expert re-evaluation

Exposure attributed by the JEM to a given subject **is checked by an expert**

Estimate by job and ascribed to each subject with this job

This Asthma-specific JEM[1] is freely available on http://asthmajem.vjf.inserm.fr/

The Asthma-specific job-exposure matrix is a two dimensional table with a job axis made up by ISCO88 job codes and an agent axis consisting of eighteen categories of asthmagenic products and 4 products at low risk for asthma. Exposure is classified as yes or no exposed. In addition, jobs poorly defined or with heterogeneous exposures (out of 506 ISCO-88 job codes) were identified and classified as 'expert re-evaluation step needed' (yes/no) with linked comments and recommendations according to each specific exposure to review. The Expert re-evaluation is an important step and a strength of the method.

When applying the JEM to a study, for a given participant, each reported job code was classified as exposed (yes/no), for each specific exposure, and as 'expert re-evaluation needed' (yes/no). In the case of re-evaluation, the exposure attributed by the JEM is checked by an expert and modified if necessary by the expert directly at participant level after taking into account his corresponding job, industry and tasks descriptions (which is the case for doctors; ISCO88 code: 2221; instructions in the expert re-evaluation step : 'recode latex=1 if surgeon). Personal care workers (code 5132) were classified as exposed to industrial cleaning products and latex. For this job, the expert step is not needed; exposure estimated for this job is ascribed to each subject with this job in the studied population.

Table E1 – Description of main studies in respiratory or immunologically –related diseases in which the Asthma-specific JEM was applied

Study Europe	Published years	Country	Design	Expert re-evaluation	Asthma or respiratory -related phenotypes			Healthy Worker Effect (HWE)	Other diseases
					Phenotypes	Exposure and disease	Jobs and disease		
ECRHS I/ II [2-6]	2004; 2007; 2014; 2016	Europe n= 1336 to 7077	Population-based	Yes	Asthma incidence Rhinitis incidence Asthma control		Cleaners, medical professions	-	-
EGEA I/ II [1,3,7-14]	2000; 2005; 2011 to 2016	France n=376 to 689	Case-control	Yes	Current, severe, work- / non-work-related asthma Biological markers	Highly reactive cleaning agents, irritants (low to high level)	Personal care workers	Hire effect Survivor effect	-
PAARC [15]	2004	France n=14151	Population-based	No	4 asthma phenotypes such as ever and adult-onset	Highly reactive chemicals and cleaning agents	Cleaners Personal care workers	-	-
B58C [16,17]	2011; 2013	UK n= 5020 to 7406	Population-based birth cohort	Yes	Adult-onset asthma	HMW, LMW, cleaning agents, irritants	Cleaning jobs	Job choices	-
RHINE [18]	2014	Northern Europe n=13284	Population-based	Yes	New-onset atopic and non-atopic asthma	LMW, cleaning agents, irritants (low to high level)		-	-
Estonian genome center [19]	2014	Estonia n=34015	Population-based	No	4 phenotypes (physician-diagnosed; current treated asthma …)	HMW (flour, animals) Low/moderate level of irritants	Cleaning jobs Healthcare workers	-	-
ISAAC/ SOLAR [20-24]	2006; 2007	Germany n=1416 to 2857	Population-based	No	Rhinitis Atopic dermatitis Allergy Sensitisation	LMW	-	Job choices Healthy hire effect	-
Lymphoma study [25]	2004	Spain n=1073	Case-control	Yes	-	-	-	-	Hodgkin's and other lymphoma
Active Swedish workers [26]	2008	Sweden n=3 million	Cohort linked to national cancer, death registries	No	-	-	-	-	Multiple myeloma
Italian Study [27]	2009	Italy n=4061	Multicenter case-control	Yes	-	-	-	-	Hodgkin's and other lymphoma
Epilymph [28]	2013	Europe n=4501	Case-control	No	-	-	-	-	Hodgkin's and other lymphoma

Table E1 – Description of main studies in respiratory or immunologically –related diseases in which the Asthma-specific JEM was applied (continued)

Study Outside Europe	Published years	Country	Design	Expert re-evaluation	Asthma or respiratory -related phenotypes			Healthy Worker Effect (HWE)	Other diseases
					Phenotypes	Exposure and disease	Jobs and disease		
Taiwan[29]	2010	Taiwan n=1512	Case-control study	Yes	Atopic and non-atopic asthma	HMW, LMW, cleaning agents	-	-	-
Apprentice cohort[30]	2009	Canada n=408	Working in animal health, technology, pastry making, dental hygiene	Yes	Sensitization	HMW	-	-	-
Apprentice cohort[31]	2014	Canada n=202	Car painting	No	incident work-related respiratory symptoms	Isocyanates	-	-	-
Clinical asthma[32]	2016	Canada n=179	Asthmatics recruited at pulmonary clinics	No	work-related respiratory symptoms	LMW	trades, transport and equipment operators	-	-
TAHS[33]	2013	Australia n=792	Cohort of children (7 years old at baseline)	Yes	New onset-asthma	Latex Highly reactive cleaning agents	Healthcare workers	-	-
Clinical asthma[34]	2014	Australia n=66	Refractory asthma	No	Biomarkers (neutrophils)	asthmagens	-	-	-

ECRHS: European respiratory survey ; EGEA: Epidemiological study on genetic and environment of asthma; PAARC: pollution atmosphérique et affections respiratoires chroniques ; ISAAC : International Study of Asthma and Allergies in Childhood / SOLAR: Study on Occupational Allergy Risks; follow-up of participants from ISAAC; TAHS : Tasmanian Longitudinal Health Study;

These papers allow evaluating (1) efficiency and accuracy of the method [1,4,8,15,30], (2) usefulness of the application of this method to study occupational exposures and asthma-related phenotypes among adults [5,7,21,29] and children[35,36], healthy worker effect [9,16,20], lymphoma immunologically-related diseases [25,27], or (3) less specific topics [37-46]. In addition, (4) some papers have revised the Asthma-specific JEM by taking into account specificities of the country[47-49] or (5) use only the method to defined large groups of exposure[50,51].

Table E2 - List of agents selected or excluded at each step - New Ocupational Asthma-specific JEM

Agents	First step included	Second step excluded	Second step included	Last step excluded
Animals	1			
Fish/ Shellfish	1			
Flour	1			
Foods	1			
Plants-related dusts	1			
Mites°	1	1		
House dust Mites			1	
Storage Mites			1	
Plant Mites			1	
Enzymes	1			
Latex	1			
Textile	1			
Moulds	1			
Bacteria*	1			1
Endotoxin	1			
Drugs	1			
Highly reactive chemicals§	1	1		
High level chemical disinfectants	1			
Aliphatic Amines	1			
Isocyanates	1			
Acrylates	1			
Epoxy resins	1			
Persulphates/Henna	1			
Wood #	1			
Metal	1			
Metal Working Fluids	1			
Irritants peaks*	1			1
Herbicides			1	
Insecticides			1	
Fungicides			1	
Indoor cleaning	1			
Bleach	1			
Organic Solvents	1			
Exhaust fumes	1			
Environmental Tobacco smoke*	1			1
Dusts, gases, fumes in general§	1	1		

° The category mites was split in three sub-categories : house dusts, storage, plant

§ Highly reactive chemical was excluded from the list but considered as a large group; Dusts, gases, fumes was excluded as may be evaluated in each study from all other exposures evaluation of the OAsJEM

* Exposure categories excluded at last step by consensus with all experts – the experts believed that these specific exposures are too difficult to evaluate by a JEM (not optimal) – Bacteria was excluded because too close to endotoxin evaluation (same exposure coding)

All kind of wood as significant associations were suggested with several wood-related jobs, not only for antigenic wood (e.g. western red cedar)[52-54]

Table E3- Examples of evaluation at various steps – Latex

ISCO-88	Standard description	Exposure level * 0:no 1:medium 2:high		Expert re-evaluation step of exposure (no/yes)
		Step 1	Step 2	
2212	Pharmacologists, pathologists	**1/1/1**	-	No
2220	Health professionals (except nursing)	1/2/1	1	Yes
2221	Medical doctors	1/2/2	1	Yes
2224	Pharmacists	1/1/0	1	No
2230	Nursing and midwifery professionals	**2/2/2**	-	Yes

* Exposure level evaluated by each expert: expert 1/ expert 2/ expert 3Consistent evaluation of exposure by the 3 experts at step 1 ➜ final decision (step 2: -)

In case of disagreement between the 3 experts regarding evaluation of exposure at step 1, the final decision was taken by consensus at step 2: in the 3 examples above, experts decided to classified these jobs with medium exposure (1) at step2.

Table E4- Examples of recommendations for medical work with high exposure to latex

ISCO-88	Standard description	Verification ISCO	Exposure	Recommendation / Comments for the expert re-evaluation step (exposure)
2221	Medical doctors	0	1	**recode latex=2** if surgeon or <u>clear evidence</u> of use of latex gloves, **recode latex=0 if clear evidence of <u>no use</u> of latex gloves (e.g. > 2000 or < 1975) otherwise keep 1** - take into account time axis, workers were considered exposed between 1975-2000 (especially in operating room; less risk as few powdered gloves after 1995-2000 and no latex gloves before 1975-1980, according to countries)
2230	Nursing and midwifery professionals	0	1	**recode latex=0** for nurses not based in hospitals (eg. public health nurse, district nurse, nurse in school, occupational health nurse, research nurse, nurse educator etc.); **recode latex=0** if clear evidence of <u>no use</u> of latex gloves (e.g. > 2000) - take into account time axis, workers were considered exposed between 1975-2000 (especially in operating room; less risk as few powdered gloves after 1995-2000 according to countries, no latex gloves before 1975-1980); **keep latex=2** for midwives, **otherwise recode latex=1**

Table E5 - Examples of jobs classified at high exposure level

Agents	n*	Examples of ISCO88 Jobs- labels
Animals	6	2223- Veterinarians; 6121- Dairy and livestock producers; 6122- Poultry producers
Fish/ Shellfish	4	6152- Inland and coastal waters fishery/ workers; 6153- Deep-sea fishery workers; 9213- Fishery, hunting and trapping labourers
Flour	2	7412- Bakers, pastry-cooks and confectionery makers; 8273- Grain- and spice-milling-machine operators
Foods	1	8272- Dairy-products machine operators
Plants-related dusts	3	6111- Field crop and vegetable growers; 6113- Gardeners, horticultural and nursery growers; 8273- Grain- and spice-milling-machine operators
House dust Mites	1	9131- Domestic helpers and cleaners
Storage Mites	0	
Plant Mites	2	6111- Field crop and vegetable growers; 6113- Gardeners, horticultural and nursery growers
Enzymes	0	
Latex	6	2222- Dentists: 2223- Veterinarians; 2230- Nursing and midwifery professionals
Textile	3	7431- Fibre preparers; 8261- Fibre-preparing-, spinning- and winding machine operators; 8262- Weaving- and knitting-machine operators
Moulds	3	6122- Poultry producers; 6124- Mixed-animal producers; 9161- Garbage collectors
Endotoxin	8	6121- Dairy and livestock producers; 6122- Poultry producers; 6124- Mixed-animal producers; 6130- Market-oriented crop and animal producers
Drugs	2	3227- Veterinary assistants; 3228- Pharmaceutical assistants
High level chemical disinfectants	3	6121- Dairy and livestock producers; 6122- Poultry producers; 7411- Butchers, fishmongers and related food preparers
Aliphatic Amines	3	7223- Machine-tool setters and setter-operators; 7224-Metal wheel-grinders, polishers and tool sharpeners
Isocyanates	1	7142- Varnishers and related painters
Acrylates	0	
Epoxy resins	4	7132- Floor layers and tile setters ; 7142- Varnishers and related painters ; 7231- Motor vehicle mechanics and fitters
Persulphates/Henna	1	5141- Hairdressers, barbers, beauticians and related workers
Wood	5	7422- Cabinet makers and related workers; 7423- Woodworking machine setters and setter-operators; 8141- Wood-processing-plant operators
Metal	7	7211- Metal moulders and coremakers; 7212- Welders and flamecutters ; 8121- Ore and metal furnace operators
Metal Working Fluids	5	7222- Tool-makers, related workers; 7223- Machine-tool setters, setter-operators; 8211- Machine-tool operators
Herbicides	7	6111- Field crop and vegetable growers; 6112- Tree and shrub crop growers ; 9212- Forestry labourers
Insecticides	9	6111- Field crop and vegetable growers; 6112- Tree and shrub crop growers; 6113- Gardeners, horticultural and nursery growers;
Fungicides	9	6111- Field crop and vegetable growers; 6112- Tree and shrub crop growers; 7421- Wood treaters
Indoor cleaning	3	5132- Institution-based personal care workers; 9131- Domestic helpers and cleaners; 9132- Helpers and cleaners in offices, hotels and other establishments
Bleach	2	5132- Institution-based personal care workers; 9131- Domestic helpers and cleaners
Organic Solvents	13	5141- Hairdressers, barbers, beauticians and related workers; 7141- Painters and related workers; 7341- Compositors, typesetters
Exhaust fumes	13	3141- Ships' engineers; 5161- Fire-fighters; 7111- Miners and quarry workers

* Number of jobs classified with 'high exposure level' for each agent. Jobs classified at medium exposure levels were not indicated in the Table.

Table E6 – Percentage of jobs classified exposed or with an expert re-evaluation - 4-digit ISCO-88 jobs (n=390)

Agents	Exposure level, %*		Expert re-evaluation, %*
	Medium or High	**High only**	
Animals	3.6	1.3	3.1
Fish/shellfish	2.3	1.0	1.8
Flour	0.8	0.5	1.0
Foods	1.3	0.3	1.8
Plants-related dusts	3.8	0.8	4.4
House dust mites	0.8	0.3	1.3
Storage mites	3.3	0.0	0.5
Plant mites	3.1	0.5	3.6
Enzymes	1.3	0.0	1.8
Latex	4.4	1.3	4.9
Textile	3.6	0.8	3.6
Moulds	6.4	0.8	2.6
Endotoxin	5.6	1.8	3.8
Drugs	1.5	0.5	2.3
High level chemicals disinfectants	8.5	0.8	4.6
Aliphatic Amines	2.3	0.5	4.1
Isocyanates	1.5	0.3	2.3
Acrylates	2.3	0.0	3.8
Epoxy resins	2.1	1.0	2.1
Persulphates/Henna	0.3	0.3	0.0
Wood	3.8	1.0	1.8
Metal	9.7	1.5	8.5
Metal Working Fluids	2.1	1.0	1.5
Herbicides	2.6	1.3	1.5
Insecticides	3.6	1.5	2.1
Fungicides	3.6	1.5	1.0
Indoor cleaning	4.4	0.8	1.8
Bleach	2.6	0.5	1.8
Organic solvents	19.0	2.8	5.1
Exhaust fumes	11.5	2.8	5.9

* percentage of jobs classified exposed at high or medium level and at high level out of 390 4-digit ISCO-88 jobs.

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